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ANALYSES OF COMPOSITE FUSELAGE STRUCTURE UNDER VARIOUS LOADING CONDITIONS

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With the unique characteristics of high strength/weight and stiffness/weight ratios in advanced composite materials, composite plate structures have been successfully applied to secondary load-carrying structural components in the aerospace industry for the past two decades. Recently, filament wound composite shells are being considered for design of primary fuselage structures. To implement the design the structural response under various loading conditions needs to be predicted accurately. Therefore, it is essential to establish a rigorous analytical solution in the area of composite laminated shells. The classical shell theory (CST) (Ambartsumyam, 1961, Dong, Pister and Taylor, 1962) based on Kirchhoff-Love hypotheses has been extensively used for analyzing laminated shells. the theory ignores the effects of of transverse shear and normal strains in the thickness direction and thus is restricted to thin shell construction. These effects are more pronounced in composite laminated shells due to the inherent strong anisotropy and non-homogeneity of the material system. Therefore, it underestimates the deflection and stress responses. Whitney and Halpin (1968) have analyzed off-axis unidirectional, two-layer angle-ply anisotropic tubes under various loading conditions based on Donnell's shallow shell approximations to characterize the mechanical properties and behavior of fiber composites. Reuter (1972) presented solutions for alternate-ply cylindrical shells using Donnell's theory. The stress field of a single layer anisotropic cylinder due to mechanical loadings was considered by Pagano (1972). Ren (1987) obtained exact solutions for cross-ply laminated cylindrical shells in cylindrical bending. Hyer (1988) has evaluated the stress distribution of cross-ply laminated shells under hydrostatic pressure. Recently, Reddy (1984) and Abu-Arja and Chandhuri (1989) have studied the behavior of moderately thick composite shells by including transverse shear deformation. Byon and Vinson (1989) used a finite cylindrical element to study the stress and displacement response in laminated anisotropic shells under external hydrostatic pressure.

In this present work a closed form solution is presented that predicts the response of a composite shell subjected to internal pressure, axial tension, bending and torsion. The material of the shell is assumed to be general cylindrically anisotropic. Based on the theory of cylindrical anisotropic elasticity coupled partial differential governing equations are developed using Lehknitskii's stress function approach. The general expressions for the stresses and displacements in the composite cylinders under these loading conditions will be discussed. Three examples: A) [45] off-axis unidirectional, B) [45/-45] unsymmetric and C) $[45/45]_S$ symmetric angle-ply fiber-reinforced laminated shells will be shown to illustrate the effect of radius-to-thickness ratios, coupling and stacking sequence.

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